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Stochastic Geometry Based Modeling and Performance Analysis of Ultra-dense Cellular Networks

by

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Certificate of Authorship/Originality

I, Junnan Yang, certify that the work in this thesis has not been previously submitted for a degree nor has it been submitted as a part of the requirements for other degree except as fully acknowledged within the text.

I also certify that this thesis has been written by me. Any help that I have received in my research and in the preparation of the thesis itself has been fully acknowledged. In addition, I certify that all information sources and literature used are quoted in the thesis.

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ABSTRACT

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In the last decade, there has been an explosive increase in the demand for wireless network data traffic. To deal with such monumental consumer requirement for information communications, several notable technologies have been proposed, such as small cell networks (SCNs), device-to-device (D2D) communications.

In the first half of the thesis, we address the critical issue of interference management in the D2D enhanced cellular network. To reduce the severe interference caused by active D2D links, we consider a mode selection scheme based on the maximum received signal strength (MRSS) for each user equipment (UE) to control the D2D-to-cellular interference. This will mitigate the overlarge interference from the D2D links to the cellular links. Moreover, to improve the capacity of D2D-enhanced networks, we consider that the typical user is no longer a random user which is selected by a round-robin (RR) scheduler, as assumed in most studies in the literature. Instead, a cellular user with the maximum proportional fair (PF) metric is chosen by its serving BS as the typical user, which is referred to as the PF scheduler in the cellular tier. Furthermore, we quantify the performance gains brought by D2D communications in cellular networks and we find an optimum mode selection threshold to maximize the total area spectrum efficiency (ASE) in the network.

In the second half of the thesis, we adjust the antenna pattern to boost the area spectral efficiency (ASE) of cellular networks when considering the height of the base stations. Very recent studies have shown that the area spectral efficiency of downlink (DL) cellular networks will continuously decrease and finally crash to zero

as the base station (BS) density increases towards infinity if the absolute height difference between BS antenna and user equipment (UE) antenna is larger than zero. Such a phenomenon is referred to as the ASE Crash. We revisit this issue by considering optimizing the BS antenna downtilt in cellular networks. We investigated the relationship between the BS antenna downtilt and the downlink network performance in terms of the coverage probability and the ASE. Our results reveal a notable conclusion that there exists an optimal antenna downtilt to achieve the maximum coverage probability for each BS density. After applying the optimal antenna downtilt, the network performance can be significantly improved, and hence the ASE crash can be delayed by nearly one order of magnitude in terms of the BS density.

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List of Publications

Journal Papers

J-1. **Junnan Yang**, Ming Ding, Guoqiang Mao, Zihuai Lin and Xiaohu Ge, Analysis of Underlaid D2D-Enhanced Cellular Networks: Interference Management and Proportional Fair Scheduler, IEEE Access, Vol. 16, No. 3, pp. 1779-1791, 2019.

J-2. **Junnan Yang**, Ming Ding, Guoqiang Mao, Zihuai Lin, De-gan Zhang, Tom Hao Luan, Optimal Base Station Antenna Downtilt in Downlink Cellular Networks, IEEE Transactions on Wireless Communications, Vol. 18, No. 3, pp. 1779-1791, March 2019.

J-3. **Junnan Yang**, Ming Ding, Guoqiang Mao and Zihuai Lin, Interference Management in In-band D2D Underlaid Cellular Networks, accepted to IEEE Transactions on Cognitive Communications and Networking, May 2019.

Conference Papers

C-1. **Junnan Yang**, Ming Ding, Guoqiang Mao and Tom H. Luan, Interference Management in Underlay In-band D2D-Enhanced Cellular Networks, in the 24th Asia-Pacific Conference on Communications, 2018. Invited Paper

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